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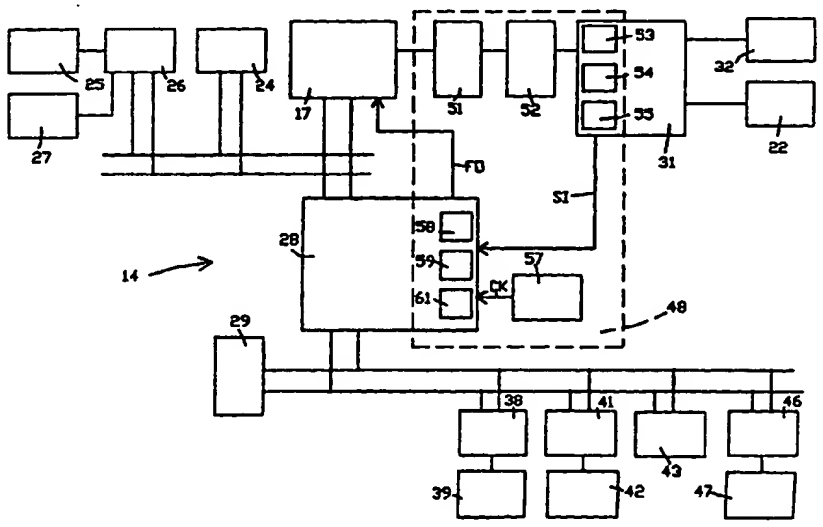

(57) Abstract

The invention concerns a device (48) for thermal control of a central processing unit (CPU) (17) having a plurality of operating frequencies. The device (48) comprises a thermal sensor (51) connected to the CPU (17) to detect the temperature thereof and to generate a resulting analog signal which is amplified by an amplifier (52) and converted into a digital signal by an analog/digital conversion stage (53). A comparator circuit (55) compares the digital signal to a predetermined temperature value stored in a memory (54) and generates an interrupt signal (SI) when the compared values are equal. The signal (SI), by means of a circuit (61) for division of the frequency of the timing signal (CK) generated by an oscillator (61), causes a reduction in the operating frequency (FO) of the CPU (17).

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DEVICE FOR THERMAL CONTROL OF A CENTRAL PROCESSING UNIT

FIELD OF THE INVENTION

The present invention relates to a device for the thermal control of a central processing unit (CPU) having a plurality of operating frequencies, comprising a thermal sensor capable of detecting the temperature level attained by the central processing unit during normal functioning thereof and generating a signal which is proportional to the temperature of the CPU.

BACKGROUND OF THE INVENTION

A device is known for the thermal control of the CPU, in which the temperature sensor is connected to a comparison circuit for generating a control signal which is indicative of exceeding a predetermined threshold which is rigidly imposed on the comparison circuit itself. When that threshold is exceeded the control signal acts directly on the control circuits of the CPU which interrupt generation of the timing signal, whereby the CPU, which then no longer performs its functions in a continuous manner, increases the length of the processing time. A reduction in the temperature below the critical limit reactivates the normal operative functions of the CPU.

That thermal control method does not permit linear control of the variation in temperature in dependence on time, thus penalising the speed of processing of the CPU for temperature values which are close to the limit value.

Another known device uses statistical/probabilistic methods for thermal control of the CPU, with algorithms which identify the limit temperature by way of the values of the level of activity of the CPU, which correspond to conditions of inactivity, equilibrium and thermal runaway. After a first predetermined period of operation at maximum frequency, there is provided an indication of temperature which is "probably" close to the limit threshold, from

which there is derived an automatic reduction in the operating frequency of the CPU. After a second predetermined period of operation at reduced frequency, there is provided an indication of temperature which "probably" returns to values of the standard, from which there is derived an automatic increase in the operating frequency of the CPU.

That method provides statistical and non-real indications and does not take account of important factors in the thermal control of the CPU, such as for example the temperature of the environment in which the CPU itself is operating.

SUMMARY OF THE INVENTION

A performed embodiment of the present invention seeks to provide a device for precise, real and continuous control of the temperature of a central processing unit, which by way of example is formed by the CPU of an electronic computer, during the normal operating condition thereof. Preferably a thermal sensor is coupled to the CPU and generates a signal proportional to the temperature of the CPU. A contral device is connected to the CPU, and to the sensor and varies the operating frequency of the CPU in dependence on the signal from the sensor.

The invention is defined with more precision in the appended claims to which reference should now be made.

BRIEF DESCRIPTION OF THE DRAWINGS

This and other features of the present invention will be apparent from the following description of a preferred embodiment given by way of example with reference to the accompanying drawings in which:

Figure 1 is a partly sectional side view of an electronic computer containing a device embodying to the invention;

Figure 2 shows an electrical block circuit diagram of the electronic unit of the computer shown in Figure 1; and

Figure 3 shows a graph illustrating the fluctuation in temperature in dependence on time for various operating

frequencies of the central unit of the computer shown in Figure 1.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to Figures 1 and 2, an electronic computer 10 on which is mounted a device 48 embodying the present invention comprises a base body 11 of substantially parallelepipedic shape and a cover 12 which is pivotally mounted on the base body 11.

Mounted on an upper surface of the base body 11 is an alphanumeric keyboard 22 provided with keys 23 for the input of alphanumeric data into the computer 10 and a display screen 25 supported by the cover 12.

In its interior the base body 11 contains an electronic unit 14 for control and management of the computer 10, which also includes the device 48 embodying the present invention. The electronic unit 14 which is shown in diagrammatic unitary manner in the block circuit diagram illustrated in Figure 2 can be produced on one or more boards 16 which, in the case of a plurality of boards, are connected and disposed in superposed relationship during assembly. The sectional view in Figure 1 shows the position of a board 16 containing a central processing unit (CPU) 17. The latter occupies the most outward position in direct contact with a lower part 18 of the body structure of the computer 10. The lower part 18 is formed by an external surface 21 of plastics material or of other equivalent material and by a metallic internal surface 19. The latter constitutes an effective radiator for dissipation of the thermal energy produced by the CPU 17 during operation thereof.

With reference to Figure 2 the electronic unit 14 further comprises a random access memory (RAM) 24, a video controller 26 for control and management of the functions of the screen 25, a read only video memory (ROM video) 27 and a read only system memory (ROM BIOS) 29.

The base body 11 also accommodates in its interior a hard disk unit (HDU) 39, a floppy disk unit (FDU) 42, a serial and parallel line management unit 43 and a PCMCIA-technology unit 47. The electronic unit 14 also comprises

a circuit 31 for control of the keyboard 22, a keyboard memory unit 32, a circuit 38 for control of the hard disk unit 39, a circuit 41 for control of the floppy disk unit 42, and a unit 46 for control of the PCMCIA unit 47.

Those components will not be further described herein insofar as they are known per se.

The device 48 for thermal control of the CPU 17 comprises a thermal sensor 51 connected to the CPU itself for detecting the temperature thereof and for generating an analog signal proportional to that temperature.

Figure 3 shows the variation in the temperature of the CPU 17 in dependence on time and for different operating frequencies of the CPU, with a frequency f1 which is greater than a frequency f2 which in turn is greater than a frequency fn. The CPU 17 increases the production of heat upon an increase in its operating frequency, whereby there is an increase in the slope of the curve in respect of thermal dissipation and a reduction in the time within which the temperature of the CPU exceeds a duty threshold T1 and reaches a predetermined limit value T2.

The power dissipated by the CPU is equal to:

$$P = C \times V^2 \times f,$$

in which P denotes the power dissipated, C denotes the equivalent capacity of the electronic unit 14, V denotes the supply voltages of the CPU 17 and f denotes the operating frequency of the CPU. It will be seen from the foregoing formula that the only physical parameter on which it is possible to act in order to be able to control the temperature of the CPU is the operating frequency.

The device 48 further comprises an amplifier 52 for amplifying the analog signal generated by the sensor 51 to a suitable voltage level and a conversion stage 53 for conversion of the suitably amplified analog signal into a resulting digital signal or "word" for example of 8 bits.

The conversion stage 53 is contained in a second processing unit, for example in the keyboard controller 31. The controller 31 also comprises in its interior a memory 54 and a comparison circuit 55 (COMP). The comparison circuit 55 compares the thermal signal which is

suitably digitized by the conversion stage 53 (A/D) to the critical temperature value T2 contained in the memory 54 (MEM). When that limit value is reached the comparison circuit 55 generates an interrupt signal SI which is indicative of that condition of coincidence.

The interrupt signal SI is read and managed by a control circuit 28 (CHIP SET)for the basic functions of the CPU 17, which receives a timing signal (base clock) CK generated by a generating circuit 57. The control circuit 28 comprises a circuit 58 for management of the interrupt signal SI, a reception circuit 59 for the signal CK and a division circuit 61 which, from the signal CK, generates a timing signal FO in respect of the operating frequency of the CPU.

By reducing the operating frequency FO of the CPU 17, a smaller amount of thermal energy is produced, and thus there is a resulting reduction in the temperature thereof. The CPU is restored to the higher operating frequency when its temperature falls below the threshold T2, to be freshly adjusted again to a lower frequency when the threshold T2 is surpassed.

The thermal control device embodying the invention permits the CPU 17 always to operate in the proximity of the maximum admissible operating frequency without uncontrolledly exceeding the limit threshold T2.

It will be appreciated that the device for thermal control of the CPU as described herein may be the subject of modifications, additions or substitution of parts without thereby departing from the scope of the present invention.

CLAIMS

1. A device for thermal control of a central processing unit (CPU) (17) having a plurality of operating frequencies (f1-fn) and comprising a thermal sensor (51) connected to said CPU for generating a signal proportional to the temperature of said CPU, characterized by control means (28) connected to said CPU and to said thermal sensor for varying the operating frequency of said CPU in dependence on said signal.

2. A device for thermal control of a CPU according to claim 1 characterized in that said signal is of analog type and that said control means comprise amplification means (52) for amplification of said signal, and analog/digital conversion means (53) for converting said signal into a digital signal.

3. A device for thermal control of a CPU according to claim 2 characterized in that said amplification means (52) comprise a amplifier stage for raising said signal to an appropriate value suitable to said analog/digital conversion means.

4. A device for thermal control of a CPU according to claim 2 characterized in that said analog/digital conversion means (53) comprise a converter for conversion of said signal into a 8-bit word.

5. A device for thermal control of a CPU according to claim 4 characterized in that said control means comprise means for the generation of an interrupt signal (81) in dependence on the attainment of a predetermined critical threshold (T2) in respect of the temperature of said CPU and means (28) for the generation of a reduced operating frequency of the CPU in dependence on said interrupt signal and said 8-bit word.

6. A device for thermal control of a CPU according to claim 5 characterized in that said means for the generation of said interrupt signal comprise memory means (54) in which the value of said critical threshold is stored, means for reading said 8-bit word and comparison means (55) for comparison of said word with said critical threshold value (T2).

7. A device for thermal control of a CPU according to claim 5 or 6 characterized in that said means for the generation of said interrupt signal (31) is included in a second processing unit.

8. A device for thermal control of a CPU according to claim 5 characterized by a generator (57) for a timing signal (base clock) and characterized in that said means for the generation of said reduced operating frequency of the CPU comprise means (58) for receiving said interrupt signal, means for division of said timing signal in dependence on said 8-bit word and means (61) for generating said reduced operating frequency in response to the division of said timing signal.

9. A device for thermal control of a CPU according to claim 8 characterized in that said means for the generation of a reduced operating frequency of the CPU are included in a controller of the basic functions (CHIP SET) of said CPU.

10. A device for thermal control of a CPU according to any preceding claim characterized in that said CPU is capable of performing the processing and controlling functions of an electronic computer.

11. A device for thermal control of a CPU according to claims 10 and 7 wherein said electronic computer comprises a keyboard (22) for the input of data characterized in that said second processing unit (31) comprises the circuit for controlling said keyboard (22).

12. A device for thermal control of a CPU according to claim 10 wherein said electronic computer comprises a body structure having at least one metallic internal wall (19) characterized in that at least a part of the external surface of said CPU (17) is held constantly in contact with said metallic internal wall, whereby said metallic internal wall performs the function of dissipating the heat developed by the CPU during the functioning thereof, permitting said CPU to operate at an operating frequency which is higher than said reduced frequency.

13. A device for thermal control of the central processing unit (CPU) (17) having a plurality of operating frequencies (f1-fn) comprising a thermal sensor (51) connected to said CPU for generating a signal in dependence on the temperature of said CPU characterised by a control means (28) connected to said CPU and to said thermal sensor for varying the operating frequency of said CPU in dependence on said signal.

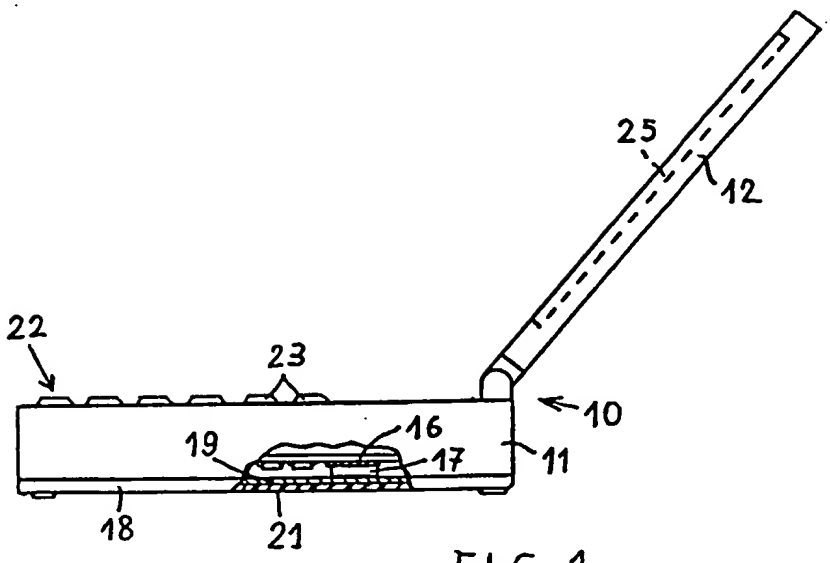

FIG. 1

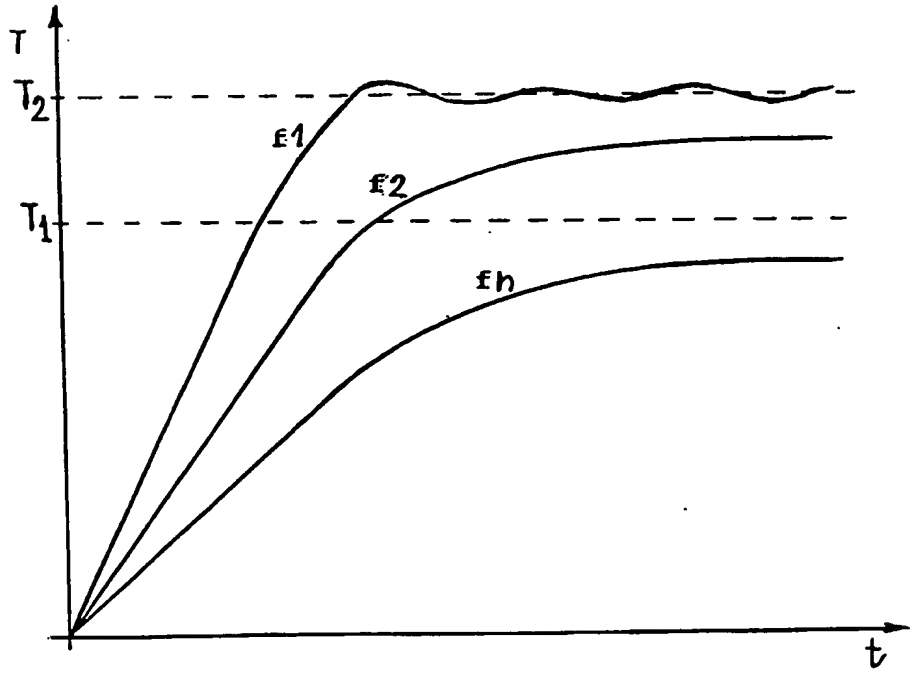

FIG. 3

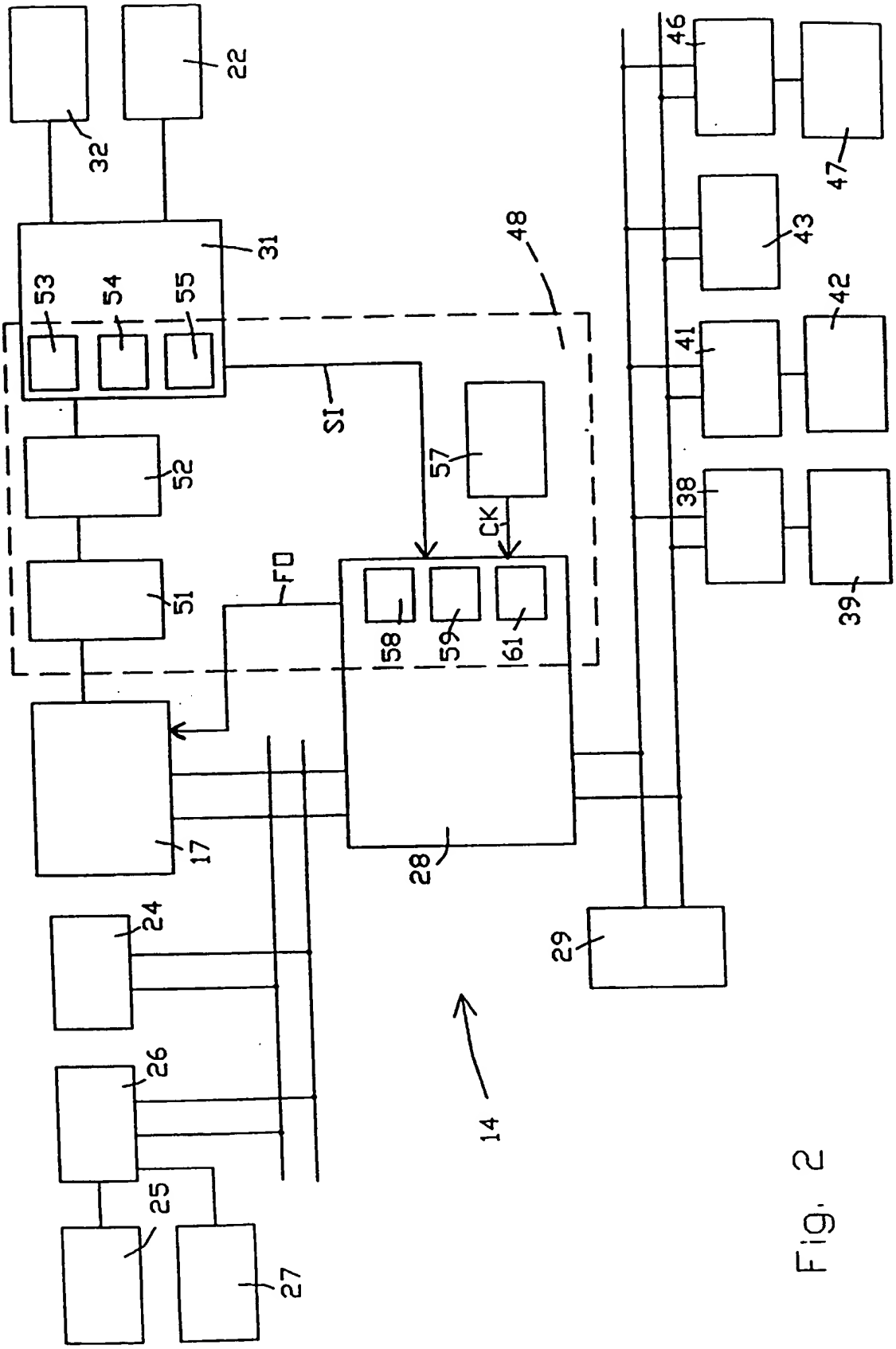
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Fig. 2

INTERNATIONAL SEARCH REPORT

Internat. Application No
PCT/IT 95/00036

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06F1/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP-A-0 489 326 (HITACHI LTD) 10 June 1992 see column 14, line 11 - column 15, line 45	1,10,13
Y		12
A		8

X	PATENT ABSTRACTS OF JAPAN vol. 017 no. 614 (P-1642) ,11 November 1993 & JP,A,05 189077 (CANON INC) 30 July 1993, see abstract	1
Y		2,3

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[X] Further documents are listed in the continuation of box C.

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3 July 1995	18.07.95
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Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 012 no. 458 (P-794) ,2 December 1988 & JP,A,63 180118 (MITSUBISHI ELECTRIC CORP) 25 July 1988, see abstract	1
Y	---	2,3
X	PATENT ABSTRACTS OF JAPAN vol. 013 no. 203 (P-870) ,15 May 1989 & JP,A,01 023317 (MITSUBISHI ELECTRIC CORP) 26 January 1989, see abstract	1
A	---	8
Y	US-A-5 237 486 (LAPOINTE BRION ET AL) 17 August 1993 see column 2, line 36 - column 3, line 5; figure 1	12

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Internat...al Application No
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EP-A-0489326	10-06-92	JP-A- 4196395	16-07-92
US-A-5237486	17-08-93	NONE	